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Integrert kommunikasjons- og energisystem (ICPS) for ekstra lange undersjøiske kabeltransmisjoner

The present invention relates to a system that combines transmission of power and signals via a custom designed cable configuration to offshore, especially subsea located control units.

To reduce the outlet of carbondioxide and other environmentally unfriendly gases, the authorities have encouraged and imposed a supply of electrical power from onshore power plants to offshore installations. For a subsea installation a power supply via a cable from land is usually the only possibility.

In addition to the power supply offshore installations are more and more dependent on data communication with land based facilities. Subsea installations may be fully controlled from land. This requires a large amount of data to be sent between the installation and land.

The principle of simultaneously utilizing power transmission cables and lines for communication purposes is commonly known under the terms "comms-on-power" or PLC (Power Line Carrier). Onshore this has been performed since long ago. Offshore it is typically applied as supplement to optical fiber cable, but may also be installed as the only system. Installed as the only system it has certain technical advantages, e.g. it may reduce the number of subsea wet mateable connectors required. The power and communications is subsequently distributed to each control unit.

Over very long distances – typically above 100 km – a combined power supply and signal communication is very difficult and the signals are subjected to disturbance from the electric current. On shore this can be solved by inserting amplifiers at certain intervals. Offshore amplifiers are not desired, since this would mean installing delicate equipment at the seabed where access for maintenance is extremely difficult.

The present invention aims to solve this problem without or at least with a substantially reduced need for amplification of the communication signals.

The invention provides overall system design considerations and implementations that have been made to achieve and optimize the above described dual functionality by utilizing a set of, preferably, four copper conductors for both power and communication signal transfer.

A further advantage of the present invention is that utilization of two conductor pairs introduces redundancy and robustness both with respect to power supply and communication, enabling continued operation of the ICPS (Integrated Communications and Power System) after the occurrence of a single failure.

The invention will now be described in detail under reference to the accompanying drawings showing illustrating embodiments of the invention, in which:

Figure 1 shows a first embodiment in a so-called quad arrangement,

Figure 2 shows an alternative embodiment in a 3 phase plus single cable arrangement,

Figure 3 shows schematically a cross section through a cable implementing the arrangement for figure 1,

Figure 4 shows schematically a cross section through a cable implementing the arrangement for figure 2, and

Figure 5 shows schematically a transformer to be used with the arrangement of figure 1.

Two alternative ways of arranging the conductors are shown in figures 1 and 2, respectively; figure 1 showing a quad system with two pairs of conductors and figure 2 showing a three phase arrangement with an additional single conductor. In both alternatives the connections are arranged and connected in an unusual way to obtain the desired ICPS system optimum. The 3 phase + 1 conductor system can be used for longer distance than the quad in the cases where the cable insulation has an outer semiconductor.

As illustrated in figure 1 and 2, the ICPS power is supplied at the onshore / topside end 1 and extracted at the subsea end 2 via multi-winding, load-balancing transformers 3 and 4.

In the embodiment of figure 1 the transformer 3 has a primary winding 5 and two secondary windings 6 and 7. The secondary windings are connected to a respective pair of conductors 8, 9 and 10, 11. Each of the secondary windings 6, 7 is equipped with a filter 12. The transformer 4 has two primary windings 13 and 14 and a plurality of secondary windings 15. Each of the primary windings 13, 14 and each of the secondary windings 15 is equipped with a filter 12.

The secondary windings15 are distributing power and signals to the various equipment on the installation.

In the embodiment of figure 2 the transformer 3 has three phase primary winding 16 and a three phase secondary winding 17. The three phase secondary winding 17 is connected to three conductors 18, 19 and 20. In parallel to the three conductors 18, 19, 20 is a single conductor 21. At each end of the conductors 18 – 21 is a filter 12.

The transformer 4 has a three phase primary winding 22 and a plurality of single phase secondary windings 15. Each of the secondary windings is equipped with a filter 12. As for the embodiment of figure 1, the secondary windings 15 are distributing power and signals to the various equipment on the installation.

Figure 3 show schematically a cross section through the cable containing the conductors 8 – 11 in figure 1. In this figure 1L1 and 1L2 denotes the two conductors 8 and 9 respectively, and 2L1 and 2L2 denotes the two conductors 10 and 11, respectively.

Figure 3 shows schematically a cross section through a cable containing the conductors 18 – 21 in figure 2. In this figure L1, L2 and L3 denotes the conductors 18, 19 and 20, respectively, and S denotes the single conductor 21.

The conductors are preferably integrated in a common cable, like the one described in Norwegian Patent Application No. 2002 0781.

Figure 5 shows schematically a transformer useful as the transformer 4 in figure 1. The transformer comprises an iron core 23, a first primary winding 13, a second primary winding 14 and a plurality of secondary windings 15.

The function and characteristics of the ICPS can be described as following:

Fixed frequency power for energizing and operation of subsea located control and communication devices is supplied to the primary winding. The connection of the power is different from the connection of the comm's on power.
a), quad: The fixed frequency power is transferred on two insulated copper conductor pairs contained in a single cable. Each pair is supplied from a dedicated power transformer winding, meaning that the two pairs are galvanically separated from each other. A filter for insertion of the communications signals is connected in-between each transformer winding and conductor pair.
b), 3+1: Power is supplied as a standard 3 phase supply. A separate core solely used for the comms' on power system forms part of the umbilical.

Transfer of communication signals within a designated frequency band via the same set of conductors used for power transmission in item.

Power and communication signals are separated at both cable ends by means of termination to custom designed filters.

The cable leading from an onshore or topside located power source is connected to a custom designed, multi-winding power transformer at its subsea located end.

a) For the quad: An integrated power and signal cable having four insulated copper conductors in fixed radial position relative to each other along the full length of the cable, as illustrated by the cross-section in figure 3. The conductors are operated in pairs as indicated, both with respect to power supply and communications signals. The signals use one conductor in each par, thus using galvanic separated signal conductors with minimum interference of the signal.
b) For the 3+1: As illustrated by the cross-section in figure 4 the single core is not located close to the 3 cores used for the power supply. The distance between the single core and the 3 power cores is determined by a number of factors such as: - minimum umbilical outer diameter, - - minimum capacitance, minimum inductance. The advantage is that the distance between the 3 cores and the standalone core can be varied, thus inductance for the comms system can be optimized.

The subsea multi-winding transformer design illustrated by figures 1 and 2 ensures that all subsea located control units are galvanically separated, and thus that the consequences of a single fault is limited to the faulty consumer.

a) For the quad: The split primary winding connections, winding 1 marked 1L1, 1L2 and winding 2 marked 2L2, 2L1 (see Figure 5), means that any control unit can be fed

from either power transmission conductor pair, thus limiting the effect of a single failure to any one of these pairs. (In the traditional case of a single primary winding and parallel connected power transmission conductor pairs, this robustness would be lost.)

Patentkrav

1.

Integrated communication and power system, comprising at least one first transformer located on shore, at least one second transformer located offshore, conductors connecting the first transformer with the second transformer, said conductors conducting electric power and communication signals, *characterized in* at least four conductors of which at least three conduct electric power, at least one of said conductors being galvanically insulated from at least one of the other conductors, the communication signals being conducted in two galvanically insulated conductors.

2.

System according to claim 1, *characterized in* that the conductors form at least two pairs in a double single phase (quad) arrangement.

3.

System according to claim 1, *characterized in* that the conductors form a three phase arrangement plus a single conductor.

Sammendrag

For å unngå signalforstyrrelser ved kommunikasjon via elektriske høyspentkabler for tilførsel av elektrisk kraft til offshore installasjoner benyttes kraftledninger som er galvanisk isolert fra hverandre. Dette kan for eksempel gjøres ved å tilføre kraft ved to énfase-par og benytte én leder i hvert par som signalleder eller ved å benytte en trefasekabel pluss en enkelleder.

<u>Figur 1</u>

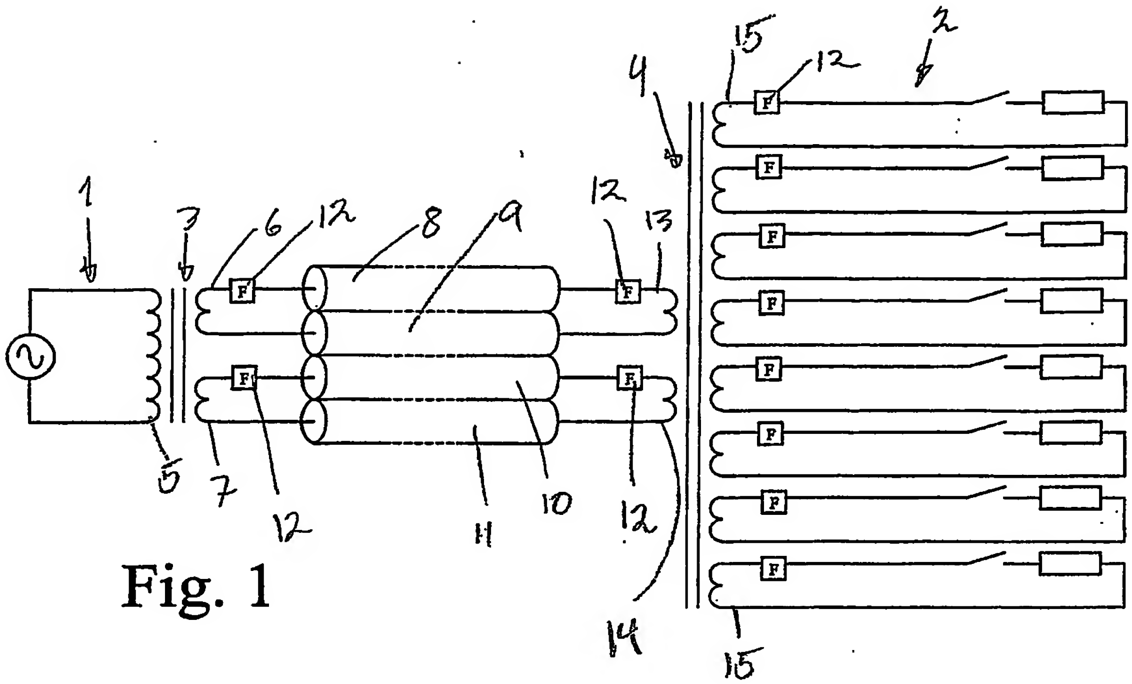
1
3
6
12
8
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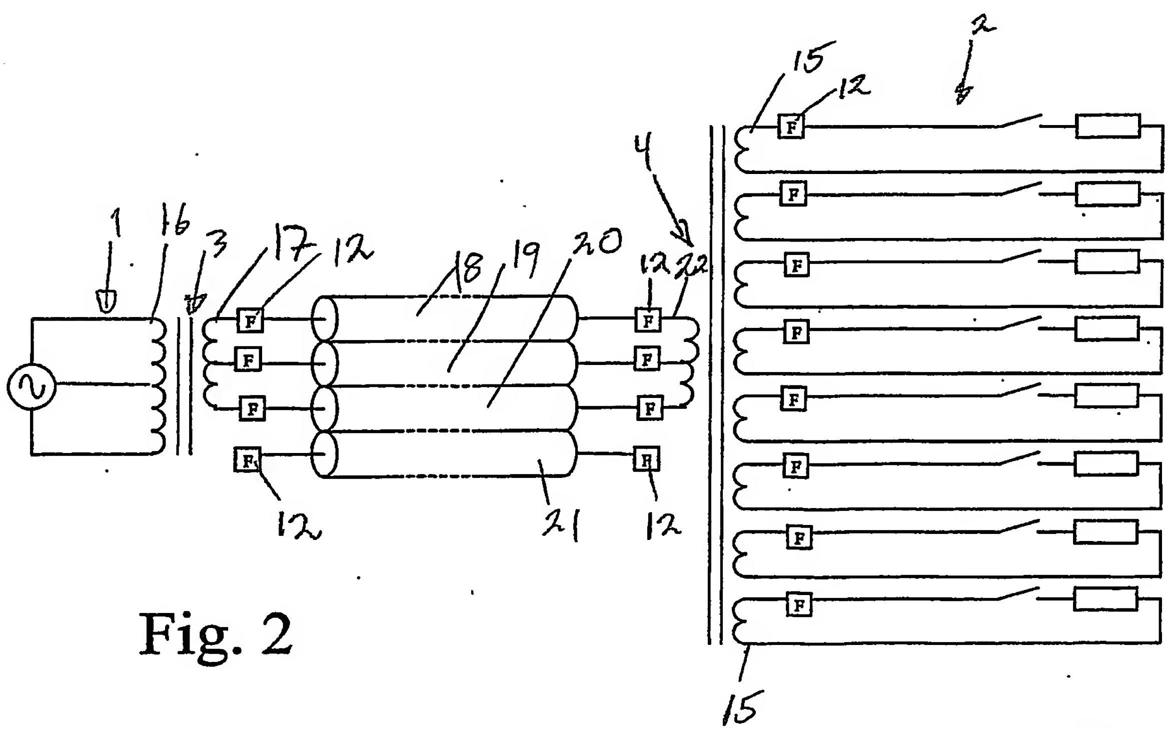
Fig. 1


1
16
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15

Fig. 2

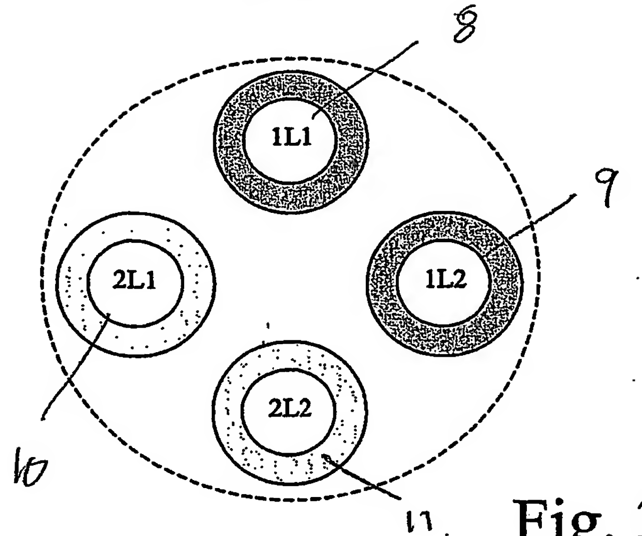

Fig. 3

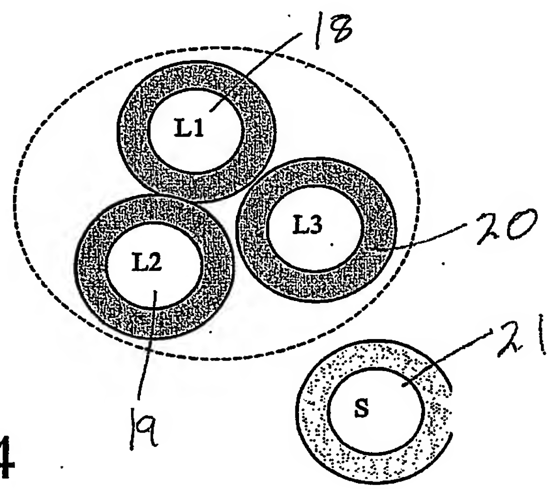

Fig. 4

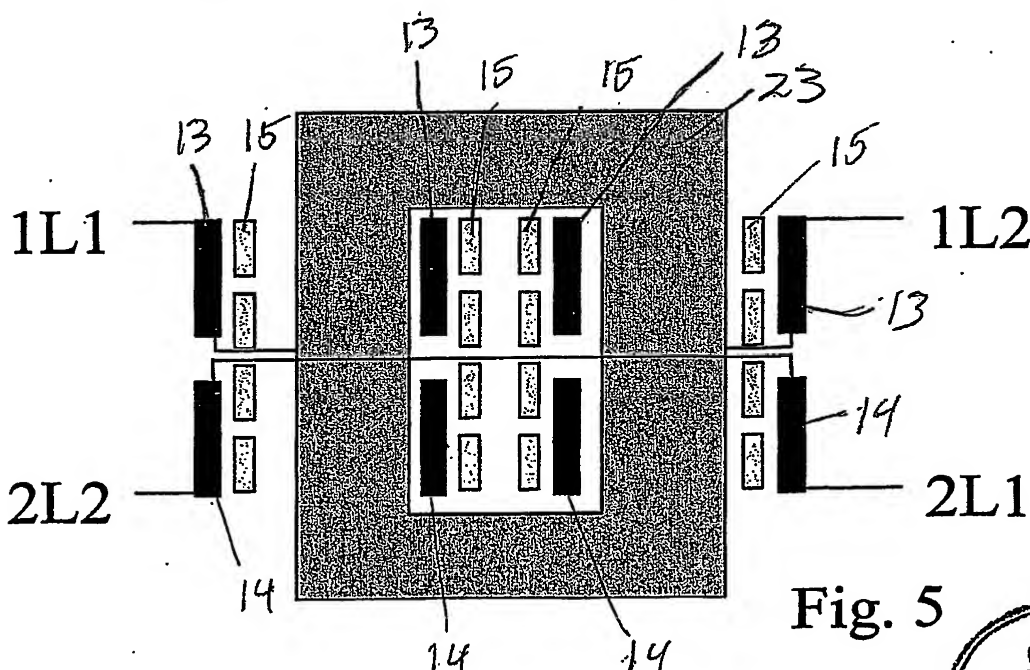

Fig. 5